Original Articles and Case Reports

ACQUIRED IMMUNITY IN LAMBS INFECTED WITH TAENIA HYDATIGENA PALLAS, 1766

By GORDON K. SWEATMAN*

INTRODUCTION AND REVIEW

Resistance to superinfection by various helminths is a common phenomenon which is generally more absolute for somatic than intestinal worms. Helminths migrating through or damaging tissues probably incite a resistance somewhat proportional to the amount of damage they cause. Data on taeniid tapeworms are reviewed. An infection confering resistance to reinfection has been demonstrated for the intermediate stage of *Taenia pisiformis* in rabbits (1 ,2, 3), *T. taeniaeformis*† in laboratory rats and mice (5, 6), and *T. saginata*†† in cattle. In Australia, Penfold, Penfold and Phillips (7) demonstrated this response in cattle against the cysticerci of *T. saginata* 23 months following their initial exposure. Soon after, Penfold and Penfold (8) reported that they had fed 400,000 ova of *T. saginata* to each of 20 cattle that had grazed four years on a pasture fertilized with urban sewage containing ova of the tapeworm. The large doses of ova failed to infect the cattle, demonstrating their immunization from the initial infections under pasture conditions. In the case of *Echinococcus granulosus*, there is no adequate evidence to show whether or not an initial infection with hydatid cysts prevents the establishment of a later infection. Secondary cysts sometimes become established following the rupture of a primary cyst which might imply the absence of acquired resistance, but, as Culbertson (9) indicated, the anaphylactic shock frequently associated in man with the rupture probably weakens the host's defenses, thus permitting an infection which might not otherwise be possible.

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†Hydatigera taeniaeformis and ††Taeniarhynchus saginatus of Wardle and McLead (4).

Residual immunity, as a sequel to acquired immunity, was demonstrated by Miller and Massie (11) for strobilocerci of *T. taeniaeformis* in rats 33 to 60 days following the surgical removal of the strobilocerci. Observations (12) on the same parasite showed that parental transfer of resistance was possible also. This, however, could not be demonstrated for the cysticerci of *T. pisiformis* in rabbits (2).

In the intestine of definitive hosts, superimposed infections have been demonstrated for *T. taeniaeformis* in both mature and immature cats (13), for *Multiceps glomeratus* in the dog (14), and for *T. hydatigena* in the dog (15); and implied also for the last parasite in timber wolves (*Canis lupus*) from northern Canada in which there occurred both gravid and quite immature worms (10). Brumpt (16) was of the opposite conviction when writing on *T. solium* and *T. saginata*. He stated that the first infection with either parasite in the intestine of man prevented a subsequent infection by the same species of tapeworm. This information, however, has not been recorded in subsequent textbooks by other writers. With reference to cross immunity, Sima (2) indicated that the presence of *T. pisiformis* in dogs brought about immunity against *T. hydatigena;* but the possibility of competition from crowding or some other unknown factor may be more significant than resistance developed by the host. It is not uncommon for both *T. saginata* and *T. solium* to exist together in the intestine of man (17, 18); and concurrent infections of *T. hydatigena, Taenia* sp. and *E. granulosus* have been observed in timber wolves (10). In a study of *T. hydatigena* in domestic and wild hosts, Sweatman and Plummer (19) included data on sequential pathological changes in intermediate hosts associated with the cysticerci of the tapeworm in various stages of development. A subsequent study, presented herein, was made to determine the degree of resistance to reinfection in relation to the amount of tissue damage in lambs following varying initial doses of ova.

PROCEDURE

It is stated generally that the degree of resistance of a host to a parasite is partially dependent on the diet of the host, its genetic constitution and age. These factors were held more or less constant in the present experiment by, (a) using purebred Suffolk lambs of the same sire, (b) exposing each lamb when three months old (91 to 94 days), and (c) by maintaining them on pasture with their ewes in a single flock. Also, twins and lambs of each sex were distributed about equally throughout the experimental groups. Dogs were infected with cysticerci from moose (Fig. 1). Ova were teased from the excreted proglottids and stored in physiological saline in a refrigerator (34 to 40°F.). A predetermined number of ova was mixed with a small amount of feed and administered in a capsule to each lamb. Following exposure, each animal was corralled individually and harnessed with a faecal-collecting bag to prevent possible contamination of the pasture as described in a previous experiment (19). The earlier study had indicated also that (a) gross lesions,

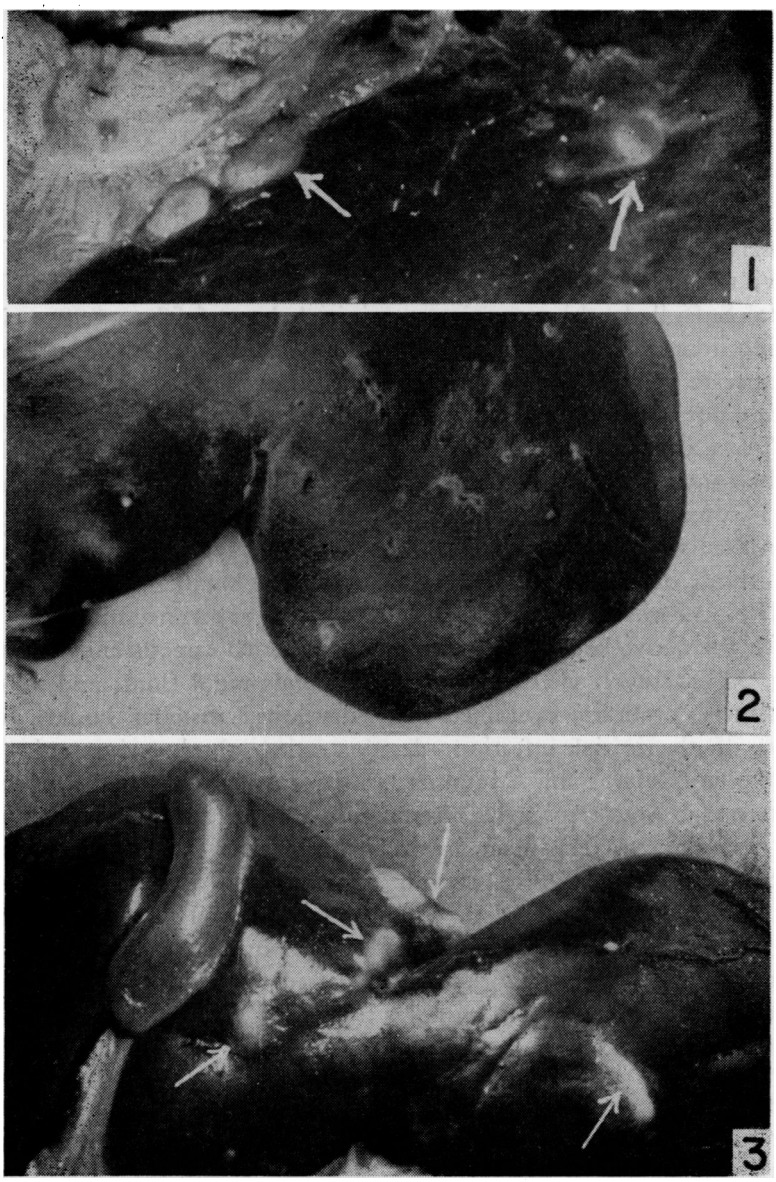

Fig. 1. Cysts of T. hydatigena in the biliary ligaments and liver of a moose.

Fig. 2. Hepatic lesions in a 20 day infection.

Fig. 3. Repaired hepatic lesions in a 10 week infection following the ingestion of 800 ova.

and (b) the state of development of the cysticerci were readily distinguishable in an infection of two to three weeks and one of 10 weeks. Hence, on the basis of these two criteria, the effect of a superinfection was determined at autopsy 10 weeks following the initial dose, and two to three weeks after the challenging dose.

RESULTS

Observations were made to ascertain the effect of administering *T. hydatigena* ova to lambs with a pre-existing infection of the same parasite. Ten experimental Suffolk lambs were given an initial dose of 50 to 800 ova, and a challenging dose of 5,000 ova seven weeks (47 to 51 days) later. The degree of resistance to reinfection was measured at autopsy 15 to 19 days after the challenging dose. By way of control, three other animals received a single dose of 5,000 ova about the time the experimental lambs received their challenging dose. The controls displayed lesions typical of a two to three week infection (Fig. 2) consisting of unrepaired, or only partially repaired haemorrhagic streaks in the liver; open pits in Glisson's capsule; as well as cysticerci in the abdominal fluid, omentum and elsewhere that were smaller than 10 mm. and had undeveloped rostellar hooks. All lambs in the experimental groups in contrast with the above had hepatic streaks replete with caseous and fibrotic matter (Fig. 3); cysticerci were absent from the abdominal fluid; and all omental and mesenteric cysticerci contained fully developed rostellar hooks. All were indicative of the initial infection, demonstrating absolute immunity to the challenging exposure. Table I summarizes the data on the number of cysticerci and lesions that were responsible presumably for the acquired resistance. Most damage was done to the liver in which the number of recovered cysticerci ranged between 4 and 38. Cysticerci in the omentum and other sites exclusive of the liver parenchyma ranged between zero and 85. Their total for any one animal, in comparison with the original number of ingested ova, indicated the approximate degree of infectivity* which varied from 4 to 44 percent. In all cases, the initial dose, some containing as few as 50 ova, protected lambs against reinfection.

This laboratory study was corroborated by observations on two Shropshire lambs that became infected initially under farming conditions common to eastern Canada. Both animals were observed at autopsy three weeks following an artificial exposure to 800 ova. One degenerate and two viable omental cysticerci were seen in one animal, and five repaired hepatic lesions and three completely developed cysticerci occurred in the omentum and mesenteries of the other. Such findings, according to the data of Sweatman and Plummer (19), indicated infections longer than a month and represented the original infections acquired naturally by the lambs. These animals, therefore, had acquired complete resistance to *T. hydatigena* under pasture conditions.

*This is somewhat greater than that observed previously for purebred Shropshire lambs (19).

TABLE I

Lesions and cysticerci in experimental lambs

Lamb Number	Sex	Number Ova in Inital Dose	Number Hepatic†† Cysticerci At Autopsy	Number Omental and Other Cysticerci†	Total No.†† of Cysticerci	Per-cent†† Infec-tivity
1	M*	50	4	2	6	12
2	F**	50	22	0	22	44
3	M	100	31	1	32	32
4	F	100	12	4	16	16
5	M	300	16	34	50	17
6	F	300	10	3	13	4
7	F	500	16	40	56	11
8	M	500	10	—	—	—
9	F	800	37	61	98	12
10	M	800	38	85	123	15
Controls						
11	F	5000	120	0	120	2
12	M	5000	51	2	53	1
13	F	5000	46	193	239	5

*Male
**Female
†Hepatic cysticerci are exclused from this figure.
††This is a minimum value since it is possible that not all cysticerci were extricated from the liver parenchyma.
—Not observed.

DISCUSSION

Although absolute acquired immunity was demonstrated in lambs in the present study, it is not known whether the response was related to the presence of the onchosphere, cysticercus, associated damage, or to combined stimuli. Szaflarski, Wisniowski and Dubiel (20) demonstrated precipitin and intradermal reactions (82 to 95% positive) for *T. hydatigena* in sheep using antigens prepared from either dried scoleces from cysticerci or from undiluted fluid from the bladder of the cysticercus. Their observations suggest that the immune response is systemic rather than localized in one or few organs. Since the present study showed that as few as 50 ova of *T. hydatigena* resulting in an infection of six cysticerci produced acquired immunity, it is most probable that heavy infections acquired naturally are from a single exposure, possibly from ingestion of one or more proglottids. This might explain the source of the hundreds of cysts of *T. hydatigena* observed by Gregson (21) in the liver and mesenteries of a two-year-old mule deer (*Odocoileus hemionus*) that contributed to its death. The experimental data suggest further that in western Canada, where large sheep flocks make an annual circuitous route principally over crown land inhabited by wild animals infected with *T. hydatigena*, lambs might be protected by the administration of 50 ova of the tapeworm soon after their birth. The resultant infection would probably cause a portion of the liver to be condemned at the time of slaughter, but the animals insofar as *T. hydatigena* is concerned, could conceivably be pastured anywhere with impunity.

SUMMARY

Absolute acquired immunity against *T. hydatigena* was demonstrated in two Shropshire lambs that became infected initially under pasture conditions in Quebec. A similar resistance was produced by 50 to 800 ova in ten three-month-old experimental Suffolk lambs as shown seven weeks later by administering a challenging dose of 5,000 ova.

RESUME

Dans la province de Québec, sur un pâturage contaminé par *Taenia hydatigena*, deux agneaux Shropshire ont acquis une immunité complète contre ce parasite. On démontre qu'il s'établit une résistance semblable chez dix agneaux Suffolk âgés de trois mois ayant reçu 50 à 800 oeufs du parasite et à qui, sept semaines plus tard, on a donné 5000 oeufs.

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INFLUENCE OF THE TEMPERATURE OF INCUBATION IN THE BRUCELLA ABORTUS RING TEST

By PAUL GENEST[1]

In a recent paper by Genest *et al* (1), it has been shown that the centrifugation of milk samples was a useful adjunct in the *Brucella abortus* Ring test. However, it was then felt that temperature was not an important factor in the mechanism of the reaction. The present study was undertaken to determine the value of this factor.

MATERIAL & METHOD

The milk samples were collected in four creameries. The Ring test was conducted according to the technique described by Genest *et al.* (1). In order that discrepancies between the periods of contact of the milk with the antigen should not be disproportionate from one sample to the other, the tests were conducted by lots of 24 samples of milk and incubated in a water-bath at 37°C. during 15 minutes. The control samples were left at room temperature (23°-25°C.) for the same length of time. Readings were taken immediately after centrifugation of the samples.

RESULTS

A total of 781 herd milk samples were examined, and 208* gave reactions varying from 1+ to 4+. No appreciable difference was noted in tests of samples incubated at 37°C. and those left at room temperature. Centrifugation proved to be the principal factor in the conspicuousness of the reactions.

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*The great number of positive reactions is due to the considerable trading in cattle in the area where the samples were collected. This constitutes a factor hindering Brucellosis control.